# CANADIAN CREAMERY BUTTERMAKING

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# CANADIAN CREAMERY BUTTERMAKING

## INTRODUCTION

A comparatively few years ago the function of the Canadian buttermaker was to manufacture butter having good flavour, body, texture, colour, etc., regardless of the percentage composition of fat, water and salt in his product. The buttermaker of to-day is required not only to manufacture butter having good workmanship, but also to control the composition of his product within very narrow limits. Economic conditions demand that the moisture content be not less than 15.5 per cent, while butter containing more than 16.0 per cent water or less than 80 per cent fat is illegal. The trade and consuming public in Canada are becoming more critical every year regarding the salt content of butter. The British market has always demanded a mild salted butter, not exceeding 2 per cent.

Butter is composed chiefly of milk fat with some water and salt and the efficient buttermaker will so arrange these constituents in his butter that the product will bring the greatest returns and conform to legal standards. It is not a difficult matter to make butter showing good workmanship, providing no attempt is made to control the composition. Similarly, it is fairly simple to control the composition of butter at the expense of good workmanship. The art of present day commercial buttermaking comprises a combination of these two factors—the control of the composition, and the manufacture of butter having good flavour, body, texture, colour, and proper incorporation of salt and moisture.

Former publications of this Branch—Pamphlet No. 52, "Neutralization of Cream for Buttermaking," and Bulletin No. 59, "The Pasteurization of Milk, Cream and Dairy By-Products"—have described the treatment of the cream in the manufacture of creamery butter prior to the churning process. The purpose of this bulletin is to treat of those processes subsequent to the pasteurization of the cream.

## CHURNING

### Churning Temperature of Cream

The temperature of the fat in the cream at the time of churning is the basic factor affecting moisture incorporation, body, texture and workmanship of butter. For this reason, it is essential that all the factors which determine the optimum churning temperature be thoroughly understood by the buttermaker in order that he may modify his methods of manufacture as conditions in varying seasons of the year require. The higher the churning temperature, the more quickly will the butter granules form. Too high churning temperatures result in greasy textured, weak bodied butter, free moisture or leaky butter, and an increase of loss of fat in the buttermilk. There is also the tendency of incorporating more than the legal percentage of water in butter that churns too quickly. Too low churning temperatures result in the formation of very firm, small, round butter granules, making it difficult to properly incorporate the salt and moisture. Such butter is usually low in moisture content and of a salvy texture.

Under normal conditions, the churning temperature should be such that the churning process takes about forty-five minutes. The length of time churning and the firmness of the butter are the chief indications regarding the correctness of the churning temperatures. A knowledge of the following factors will assist the buttermaker in controlling the churning and subsequent processes in the manufacture of creamery butter.

Up to 35 per cent fat, the richer the cream the less time required to complete the churning process and the lower the churning temperature should be to ensure exhaustive churning. Cream containing more than 35 per cent fat tends to stick to the sides of the churn and receives less agitation, thus prolonging the time of churning. Best results are obtained from cream containing 30 to 33 per cent fat.

The speed of the churn is an important factor affecting the length of time churning and also the loss of fat in the buttermilk. Too low or too high a speed increases the length of time churning. The optimum speed is one which gives the greatest agitation to the cream, but since it varies according to the make of churn, amount of cream in churn, and richness of the cream, it must be determined by the individual operator.

The greater the amount of cream to be churned, the slower will be the length of time churning. On the other hand, if too small an amount of cream be used, it will revolve with the churn and receive little agitation. The most satisfactory results are obtained when the churn is from one-third to one-half full of cream. Overloading the churn is a very common cause of uneven coloured butter.

It is difficult to avoid a weak textured butter and excessive loss of fat in the buttermilk when the cream is churned immediately after pasteurizing and cooling. The cream should be held at least two hours after cooling before churning. Occasionally, force of circumstances compels churning immediately after cooling, in which case the cream should be cooled to a lower temperature than the usual churning temperature. During the summer months, cream that is to be held after cooling on Saturday until Monday should be cooled to a lower temperature than cream held over one night.

In the winter, there are several factors inducing firm butter fat, thereby increasing the tendency of butter to be hard and brittle and the difficulty of incorporating the desired amount of water without making the butter sticky. Butter fat is composed of nine different kinds of fats, viz., Butyrin, Caproin, Caprylin, Caprin, Laurin, Stearin, Myristin, Palmitin and Olein, some of which are hard and some soft The proportion in which the hard and soft fats occur in milk is determined largely by the kinds of feed fed to the cows. The usual feeds fed in the winter produce butter fat rich in the harder fats, hence, unless the necessary precautions be taken, butter made at this time of year is often hard, brittle and sticky. In the spring when the cows are turned out on pasture, a larger proportion of the soft fats occur in the butter fat and the buttermaker is faced with the problem of so controlling the churning temperatures and the temperature of the wash water that the resulting butter will not be too soft. In addition to the kind of feed fed to the cows, the size of the fat globules in the cream affects the firmness of the butter. Large fat globules result in a comparatively soft butter, while cream containing small fat globules tends to produce butter with a firm body and brittle texture. The size of fat globules is largest at the beginning and gradually decreases towards the end of the cow's lactation period. Hence, more trouble is experienced from this source in winter owing to the large number of cows well advanced in their lactation period.

From the foregoing brief remarks concerning the nature of cream and butter fats, it is apparent that buttermaking consists of something more than the mere mechanical operation of running cream into a churn and allowing the machinery

to complete the process. Unless these principles be thoroughly understood by the buttermaker, he cannot intelligently control the workmanship of his butter, comprising moisture and salt incorporation, body, texture and colour.

Before using, it is recommended that churns be steamed or rinsed first with hot water at least 180° F., and then rinsed and cooled with cold water. In cooling, a large volume of cold water should be run into the churn and the latter revolved in slow gear a long time. The practice of giving a few revolutions with only a small volume of water in the churn does not thoroughly cool the churn, neither does it close the pores in the wood, and the result is a "greasy" condition of the churn. The sticking of the butter is sometimes due to a greasy churn. The cream should be strained into the churn to remove particles of curd which would otherwise cause white specks in the butter and to prevent the entrance of insoluble foreign matter.

### Adding Colour

The natural colour of butter fat varies with the different breeds of cows, the stage of the lactation period and the feed. When feeding on green pasture, cows produce butter fat of a bright golden colour. Dry feed results in butter fat that is only faintly yellow. As the lactation period advances, the colour of the butter fat becomes lighter. These varying conditions make it difficult to maintain a uniform colour throughout the different seasons and call for close attention on the part of the buttermaker. The demands of the market determine the amount of colour (if any) per hundred pounds of fat to be added to the cream. For export to the European markets, a light straw-coloured butter is desired. The important point is to decide on the colour best suited to the particular market in which the butter is to be sold and to maintain that same shade of colour with each churning. This is especially true of export butter in which uniformity plays such a big role in establishing the reputation of our butter in the Old Country. In addition to the lack of uniformity of colour in different churnings of butter from one creamery and the danger thereby of the whole shipment being placed in second grade, there is also the certainty of some boxes being graded seconds because of "two colours" caused by a portion of two churnings being packed in the same box. A uniform shade of colour in different churnings of butter can only be obtained by knowing the number of pounds of fat in each churning, keeping accurate churning records in which are included the number of ounces of butter colour per hundred pounds of fat used in each churning, checking the colour of each churning of butter with a reliable butter colour rod or chart, and by using this information to determine the amount of butter colour to add to the next churning. Even in those seasons when it is not necessary to add any butter colour the colour of different churnings is not always of the same shade. This is caused by some of the churnings being worked more than others, the former having the lighter shade. Churnings of butter made from cream produced in different sections of the country sometimes vary in shade of colour owing to local conditions of breed of cows and feed.

Lack of uniformity in different churnings of butter must not be confused with uneven colour in one and the same churning. In the former, the colour of each churning may be perfectly even, although the shade of colour in the different churnings would not be the same.

The butter colour should be added to the cream before the churn starts to revolve. If this be forgotten, the colour may be mixed with the dry salt prior to applying the latter to the butter. This method tends to give the butter an uneven colour and should never be employed except in cases of necessity.

### Churning

During the first five minutes of churning, it is advisable to open the vent of the churn once or twice to release the pressure caused by the expulsion of gases from the cream and the expansion of air in the churn.

The churning is completed when butter granules the size of wheat kernels are formed, at which stage the churn is stopped and the buttermilk run off through the strainer. If the churn is stopped when the granules are smaller than those specified the loss of fat in the buttermilk will be increased. Over-churning, or allowing the churn to rotate until the granules are much larger than small corn kernels, results in (1) a poor keeping quality butter owing to the incorporation of an excessive amount of buttermilk, (2) a salvy or greasy texture if the churning temperature of the cream is normal, and (3) a high moisture content in the butter when overchurning is caused by too high a churning temperature creating a soft condition of the butter fat.

The butter granules should be neither too firm nor too soft, the ideal condition being obtained when the butter is slightly resistant to the pressure of the finger. Butter lacking this resistancy tends to have a weak body and incorporates moisture too readily. Butter that is too firm absorbs moisture very slowly, hence the danger of either salvy, overworked texture, or a low moisture content. The efficient control of the composition and workmanship of butter depends on the firmness of the butter granules, which in turn is dependent on the natural firmness of the butter fats and the treatment of the cream prior to churning. It has already been stated that the natural firmness of the butter fats varies according to the feed fed to the cows and the stage of the lactation period. Fortunately, the *actual* firmness of the butter fat can be controlled by the temperature of the fat in the cream at the time of churning. For example, in the spring of the year when the fats naturally become softer, the churning temperature should be lowered sufficiently to maintain the desired firmness of the butter granules. In the fall, when the butter fats become firmer, the churning temperature should be correspondingly raised.

## WASHING, WORKING AND SALTING THE BUTTER

### Temperature of Wash Water

Pure water only should be used for washing the butter. While the primary object of washing the butter is to remove the remnants of buttermilk still adhering to the granules, within certain limitations it may serve to correct the defects which otherwise would result from too high or too low churning temperature, or from churning the cream too soon after pasteurizing. For example, if the butter granules are too soft or too firm, the temperature of the wash water should be lowered or raised respectively. However, when the variation between the temperature of the buttermilk and that of the wash water exceeds more than three or four degrees, there is always the danger of uneven colour in the butter, caused by the outside of the granules being softer or harder than the centre. Under normal conditions, i.e., when the cream has received the proper care prior to churning, the temperature of the wash water should be within two or three degrees of the temperature of the buttermilk.

When the buttermilk has been removed, the butter granules should be sprayed with water at the proper temperature until the wash water runs fairly clear from the buttermilk gate. It is not advisable to allow the cold water to flow on any one portion of the butter granules for long at a time, as such a practice may result in uneven coloured butter caused by the granules with which the water comes in contact being hardened more than the others.

So far, the various processes described in the manufacture of creamery butter are in common practice by most buttermakers. The methods subsequent to this stage, i.e., the manner of working and salting the butter, fall into two groups, each of which is either criticized or advocated by both practical buttermakers and dairy scientists, according to their results. The writer has obtained good results in the commercial field with both methods and, therefore, will describe each. The objective is well-made butter containing fat, moisture and salt in the desired proportions. The method that will accomplish this for the individual buttermaker is the one that should be practised.

### Working and Salting—Method I

After thoroughly spraying the butter granules, the washing is completed in the following manner. The buttermilk gate is closed and about 150 gallons of wash water for a thousand pound churning of butter are run into the churn; smaller sized churnings of butter require proportionately less amounts of wash water. The butter is then worked in the wash water—the workers in low gear and the churn doors, gates, etc., closed—until it is formed into lumps the size of cocoanuts or larger. After completion of the required number of revolutions in the wash water, the latter is drained through the doors, the churn stationary, until the water runs away in a very small stream. Many small granules will float out with the water if the butter has not received sufficient working in the wash water. The churn is then given one revolution, the workers active and in low gear and drained again. This is repeated until practically all the loose moisture has drained from the churn. An extra gate, placed in the centre of the churn in line with the buttermilk gate, facilitates the draining of the loose water.

The art of buttermaking cannot be reduced to any " rule-of-thumb " and, therefore, it is impossible to state the required number of revolutions working in the wash water and draining. The buttermaker must be guided in this respect by judgment and experience. The draining away of the loose moisture is a very important step in this method and, other conditions being the same, is determined largely by the " preliminary moisture test " of the previous churning. The preliminary test should show a moisture content of about 15 per cent; a variation over or under 15 per cent would, therefore, indicate insufficient or excess draining respectively. For example, supposing five revolutions draining results in a preliminary test of 15.8 per cent, the number should be gradually increased with subsequent churnings until the preliminary moisture content is 15.0 per cent. When the butter has a tendency to incorporate excess moisture, the draining revolutions should be continued until the water does not drain in " small streams ", but trickles drop by drop. In addition to the preliminary moisture content of the previous churning, the condition of the granules in the present churning must also be considered in determining the degree of draining. Soft butter mixes with and holds moisture more readily than firm butter and, therefore, the former condition would indicate more extensive draining than the latter in order to obtain corresponding results as shown by the preliminary moisture test. Overchurning, when resulting from too high a churning temperature, tends to increase the moisture content. On the other hand, churning until very large granules or lumps are formed, providing the churning temperature be normal, lessens the amount of water held in the butter. Churning to a very fine granule increases the water content. A large churning of butter incorporates moisture more readily than a small one. The proper treatment of the cream prior to churning, as previously described, together with close attention to stopping the churn when the granules are of the desired size, ensures the correct consistency of the butter and size of granules, so that under normal conditions the preliminary moisture test of the previous churning is a safe guide as to the number of revolutions draining.

With this method of working and salting, *all* the salt that is applied is incorporated in the butter, so that the salt content of the butter can be accurately controlled by the buttermaker providing he knows the number of pounds of butter fat in the churning. Methods which require draining after the application of salt not only increase the difficulty of accurately controlling the salt content of the butter, but also result in a needless financial loss in the course of a season's make, some operators retaining in the butter as little as fifty per cent of the salt applied. The amount of salt to apply may be determined as follows:—

1. Calculate the number of pounds of butter expected from the pounds of fat in the churning of the cream. This will vary with the composition of the butter and the efficiency of manufacture—in other words, with the percentage of overrun. Assuming that the overrun be 23 per cent, 123 pounds of butter are obtained from 100 pounds of fat, so that the pounds of fat in thc churning multiplied by 123 and divided by 100, give the pounds of butter expected.
2. Calculate the number of pounds of salt from the pounds of butter.

*Example.*—Churning contains 800 pounds fat.

Expected amount of butter $\frac{800 \times 123}{100} = 984$ pounds.

Required percentage of salt in the butter = 2.0.

Therefore $\frac{984 \times 2}{100} = 19.68$ pounds of salt to apply.

The foregoing calculations should be made as soon as the number of pounds of fat in the churning are known and placed on the churning record for the guidance of the churn operator rather than waiting until the time for adding the salt.

The amount of salt may be based on the pounds of butter fat in the churn, as calculated by the weight and test of the cream, but since it is advisable to know the amount of butter expected for purposes of moisture control, preparation of boxes, etc., no extra work is involved by determining the amount of salt from the pounds of butter.

The salt is applied to the butter by distributing it evenly in a trench extending the whole length of the churn. The trench is then sealed over and, with the churn doors and all openings closed, the working is continued until a representative sample of butter is obtainable for the preliminary moisture test. The exact number of revolutions cannot be stated, as they will vary according to the condition of the butter and the type of churn. The desired condition is reached when all the free moisture in the churn is evenly distributed throughout the butter, though not so thoroughly incorporated as in the finished butter. An examination of a portion taken from the interior of the butter should show very small drops of water on the surface. If the working is continued beyond this stage, there is danger of injuring the body and texture of the butter in the subsequent working. On the other hand, if the working is stopped before this condition has been reached, the moisture will not be evenly distributed throughout the butter and the preliminary moisture test will not show the correct water content, thus making it impossible to accurately control the moisture content of the finished butter. A representative composite sample is taken from four equidistant parts of the interior of the butter and tested for moisture. As previously stated, this preliminary moisture test should show a water content of about fifteen per cent in the butter. The amount of water necessary to increase the moisture content from that shown by the preliminary moisture test to that desired in the finished butter is determined in the following manner. The pounds of butter expected are multiplied by the difference between the

preliminary moisture test and the desired moisture content of the finished butter and the result divided by 100, e.g.

| | |
|---|---|
| Pounds of butter expected.. .. .. .. .. .. | 1,000 |
| Desired final moisture content.. .. .. .. .. | 15.5 per cent. |
| Preliminary moisture test.. .. .. .. .. .. | 14.8 per cent. |
| Difference.. .. .. .. .. .. .. .. .. .. .. .. .. | 0.7 per cent. |

Therefore $\frac{1,000 \times .7}{100} = 7$ pounds of water to add

The required amount of water is weighed accurately, added to the churn and the working of the butter continued until the moisture is thoroughly incorporated. The manner of determining just when the final working is completed is similar to that described prior to making the preliminary moisture test, except that no free moisture or only extremely small droplets should appear on the surface of a portion taken from the interior of the butter. Underworking results in leaky or free moisture butter and uneven colour, while overworking damages the body and texture. The best judgment of the buttermaker must be used to ensure that the butter receives just sufficient working to thoroughly incorporate the moisture and no more. A final moisture test should be made before removing the butter from the churn.

A word of caution should be given to those buttermakers who are aiming to incorporate the maximum legal percentage of water, viz., 16 per cent in the butter. Unless the churn be absolutely level and the workers in good order, the moisture content in different parts of the churning will not be uniform. In other words, while the composite sample of butter may show 16 per cent moisture, part of the churning would contain less and another portion more than the legal moisture content. In order to avoid the danger of manufacturing illegal butter, it is advisable to determine the moisture content in different portions of the churning from time to time.

The following modification of the foregoing method of working and salting is sometimes practised. Instead of incorporating the salt before making the preliminary moisture test and adding the necessary amount of water to bring the final moisture content to 16 per cent, a moisture test is made immediately after the last draining revolution. The required amount of water is then added to the churn with the salt and the working of the butter continued, all doors and openings closed, until the moisture and salt are thoroughly incorporated. The improbability of obtaining a representative sample of butter for the preliminary moisture test at this stage (after the last draining revolution) increases the difficulty of efficiently controlling the moisture content of the finished butter, although with uniform methods from day to day, good results are being obtained by creameries practising this modified method.

## Working and Salting—Method II

After spraying the butter granules, the washing is completed by adding as much water as there was buttermilk and giving the churn from eight to ten revolutions, the workers not in gear. Butter made from cream of poor quality should be given a second washing with fresh wash water. The wash water is then thoroughly drained from the churn and the salt applied evenly, either by sprinkling over the granules or by trenching as previously described. The moisture content of butter at this stage normally exceeds 16 per cent and, therefore, draining must be practised after the application of the salt. Since some of the salt is lost during this subsequent draining, more than the amount of salt required in the finished butter must be applied. The percentage of the applied salt which is retained in the butter varies with local conditions, quality of salt and

methods of manufacture, so that each buttermaker must determine for himself the rate of salt per pound of butter fat to apply. As a guide, it may be stated that under average conditions, from one-quarter to one-half of the salt applied is lost during draining.

After the application of the salt, the workers are put in low gear and the working of the butter continued until the moisture and salt are thoroughly incorporated. The amount of draining required to ensure that the moisture content of the finished butter does not exceed 16 per cent varies with such factors as size of granules, firmness of the butter, etc., described under Method I and the type of churn. It is truly an art to determine the amount of draining after applying the salt and requires the best judgment and experience on the part of the buttermaker. If too much water is left in the churn, the butter may contain the maximum legal moisture content before it has received sufficient working and will be leaky and in all probability uneven in colour. On the other hand, if draining has been carried to excess, the finished butter will be too low in moisture. The usual practice is to make a moisture test before the working is completed and either to add the necessary amount of water to bring the final moisture content to the desired per cent or, if the moisture content is already more than 16 per cent, to drain off the excess water. The working is then continued until all the free moisture is thoroughly incorporated (as described in Method I, page 9) and a final moisture test made before removing the butter from the churn.

## PACKING AND PRINTING

There are three methods of packing and printing butter commonly practised by Canadian creameries, viz.:—

I. Removal of the butter from the churn to a table and printing into brick shaped one-pound prints, or flat oblong two-pound prints by means of a hand printer.

II. Packing the butter from the churn into specially made 90-pound boxes, firming in cold storage overnight, and cutting the butter into one-pound prints by means of a printing machine the following morning.

III. Packing the butter from the churn into 56-pound boxes and selling same as "solids."

### I.—Hand Printing

Before removing the butter from the churn to the table, the latter should be well scrubbed with a brush and boiling water and then thoroughly cooled with cold water. A few handfuls of salt sprinkled over the table and brushed in well with the hot water prevents the butter from sticking to the table. The hand printer and butter ladles should also be scalded and thoroughly cooled before using.

The Canadian law requires that one and two-pound prints of butter shall weigh not less than one and two pounds respectively when purchased by the consumer. Therefore, owing to the fact that butter loses some of its water content during storage, more than the required legal weight of butter must be put into each print. Just how much more will vary with such factors as length of time elapsing between manufacture and ultimate sale of butter to the consumer, temperature of storage, and the efficiency with which the moisture and salt content has been distributed throughout the butter. Under average conditions, the pound print with wet wrapper should weigh $16\frac{1}{4}$ ounces when printed. The hand printers are adjustable to print the desired weight of butter; economic conditions demand that the print shall be of sufficient weight, but not more than

the law requires. This is one of the important factors affecting the overrun in butter and, as such, demands the constant attention of the creamery operator.

The prints should have square corners, be free from holes or finger marks and be neatly wrapped in good quality parchment paper. The following method of avoiding mould contamination from butter wrappers is described in Bulletin No. 48 "The Cause and Prevention of Mould in Canadian Pasteurized Butter," copies of which may be obtained free from the Publications Branch, Department of Agriculture, Ottawa.

"TREATING PARCHMENT LINERS AND WRAPPERS

"Parchment liners and butter wrappers should be properly stored, thoroughly treated before using and be of suitable weight. All liners and wrappers should be stored in a clean, dry place, in the original package until used. A paper of 40-pound weight or over is recommended for lining 56-pound boxes. Treatment:

"Make up in a wooden or fibre tub, a brine solution in the proportions of one gallon of water to four or five pounds salt. Sufficient of this solution should be used to completely cover the parchment papers. Count out from the original package sufficient liners or wrappers for the following day's make and place loosely in the brine solution, so that the heat will penetrate to every liner. Bring brine solution to the boiling point by the use of steam and continue boiling for five minutes. During the heating period, see that all liners and wrappers are submerged in the salt solution. Place a suitable cover over the tub and allow liners and wrappers to remain in brine solution until next day. This will expose them for a considerable time to the necessary heat to destroy all yeasts and moulds and they will be cool, ready for use on the following day.

"Brine may be repeatedly used, but should be kept up to full strength and changed every seven to ten days.

"Formaldehyde solutions have been successfully used for the treatment of parchment liners. It is most important, however, that such solutions be of proper and maintained strength and this is often neglected in the average creamery. Carelessness or neglect in use, results in weak solutions which are ineffective in destroying mould and, at the same time, giving a false sense of security to the buttermaker. Formaldehyde solutions deteriorate rapidly, leaving the buttermaker with no way of determining their strength. However, he can always be sure of having a boiling brine solution and, for this reason, such treatment for liners and wrappers is recommended."

## II.—MACHINE PRINTING

The 90-pound boxes should be thoroughly scalded and cooled before packing the butter into them; otherwise, trouble will be experienced with the butter sticking in the subsequent printing. Care must be exercised in the pounding of the butter into the boxes to avoid holes or "pockets," which necessitates additional work of "patching" the prints when the butter is later cut into pound blocks. It is difficult to properly pack butter which is very firm; when this condition obtains, the man removing the butter from the churn will facilitate the work of the operator handling the pounder by placing relatively small spadefuls of butter in the boxes at a time and allowing same to be well packed down before adding more butter. When all the butter has been removed from the churn, the surface of the butter in the boxes should be levelled by means of a wooden draw-knife or butter spade. The butter is then held in the refrigerator until it is firm enough to be cut up into pound prints. The usual practice is to hold the butter overnight and print the following morning.

There are various styles of printing machines on the market; some are operated by a ratchet gear, while others are hydraulic. The operation for all styles is the same. The box of butter is placed on the base of the machine, the cutting frame put on top of the box and clamped down tightly. A few movements of the wooden lever arm forces upwards the loose bottom in the box. The butter is thus passed through the wires of the cutting frame which cuts the butter into the proper width and length. By drawing the bow knife across the top the butter is formed into one-pound prints.

The bow knife is adjustable to cut prints of the desired weight and, owing to the important effect of the weights of the prints on the overrun and the necessity of complying with legal standards (see I—Hand Printing, page 10), its adjustment should receive the careful attention of the operator. As an added precaution, *every* print from the machine should be weighed and, if necessary, a sufficient amount of butter added to or removed from each print to ensure that it be of the correct weight. The fact that our most successful and up-to-date plants are following this practice should recommend its adoption by the smaller creameries.

The factors affecting the required weights of pound prints, the treatment of butter wrappers to avoid mould contamination and the wrapping of prints, were described under I—Hand Printing, page 10.

When printing with a machine, there is always a certain amount of "scraps"—butter left over from each box after the 90 pounds have been cut out. This may be printed by a hand-printer, or added to the cream in the churn just prior to churning, providing it is cut up into small portions and not more than the scraps of one churning of butter added to each churning of cream. Another method is to repack the scraps in a 90-pound box and print with the machine; each churning must be packed in a separate box to avoid "two colours" in the prints.

## III—Solids

Practically all Canadian butter sold as solids is packed in 56-pound cube-shaped boxes. Only well seasoned, clean, strong and well paraffined boxes should be used. After lining the boxes with good parchment paper which has been previously treated as described under "Treatment of Liners and Butter Wrappers," page 11, each box should be weighed and the weight marked in pencil on the side of the box. The following table gives the number of boxes which should be prepared for various sized churnings of butter:—

| Number of lbs. Butter | Number of Boxes Required |
|---|---|
| 500 | 9 |
| 600 | 11 |
| 700 | 13 |
| 800 | 15 |
| 900 | 16 |
| 1,000 | 18 |
| 1,100 | 20 |
| 1,200 | 22 |

In packing the butter from the churn into the boxes, the utmost care must be exercised to avoid "pockets" in the interior of the butter and rough corners. If these defects occur, the butter presents a most unfavourable appearance when exposed on the counters of the retail stores in the United Kingdom, thereby damaging the reputation and lowering the price of Canadian butter in the Old Country markets. When such butter is consumed in Canada, it is very objectionable to the trade in that the labour of cutting it into pound prints of correct weight and neat appearance is increased.

Each creamery must determine for itself the necessary amount of butter to pack in each box to ensure that the ultimate buyer receives 56 pounds of butter per box. The factors which affect the amount of shrinkage in butter have already been discussed under I—Hand Printing, page 10. In this connection, it should be noted that the rules governing the weighing of butter for the city of Montreal state that " When averaging or weighing butter, an allowance of one-quarter pound over and above the balance of the beam must be made to ensure good weight and to cover parchment paper, which is not to be removed when weighing ". The usual practice is to allow one-half pound for shrinkage, so that in weighing the boxes of butter each box should have a gross weight of 56½ pounds plus the weight marked in pencil on the side of the box.

Too much emphasis cannot be laid on the importance of finishing the surface of the box so that it presents a clean, level and attractive appearance. Apart from the general appearance of the exterior of the box, the surface of the butter is the first impression which the buyer receives and, therefore, a big factor in establishing a reputation for high quality butter. The use of the " Gibson " roller for giving a corrugated surface on 56-pound boxes of butter is strongly recommended. This roller with directions for using may now be purchased from the dairy supply houses in Canada. In New Zealand the use of a roller for finishing the surface of butter has been practised for at least twenty-five years. After finishing the surface of the butter, the liners should be folded over neatly, the lid nailed on, the necessary marks stencilled on the end of the box, and the butter immediately placed in the refrigerator.

Uniformity in the appearance of 56-pound butter boxes, including type of box, style of branding, position of marking creamery registered number and churning number, is essential to the success of Canada's butter industry. The grade standards for first and special grade butter require so far as the " packing " or " finish " is concerned that the boxes must be well seasoned, clean, strong and well paraffined. The parchment paper must be of good quality and neatly arranged. The number of churning must be plainly marked on all boxes and the butter solidly packed, full weight and properly finished. In other words, the highest quality of butter cannot be placed in special or first grade if it be packed in boxes which do not conform to the foregoing standards.

Any butter on which mould has appeared either on the butter itself or on the parchment paper lining of the package is classified as " no grade ".

For detailed information regarding the grading and marking of butter boxes, the reader is referred to the following publications which may be obtained free from the Publications Branch, Department of Agriculture, Ottawa: Circular No. 20, " Vat and Churning Numbers on Cheese and Butter Packages "; " The Dairy Industry Act, 1914, as amended in 1923, Acts, Orders and Regulations No. 13 "; and " The Dairy Produce Act as amended in 1925 and Regulations, Acts, Orders and Regulations No. 17 ".

## CLEANING EQUIPMENT

It is not sufficient that vats, pumps, pipes and churns be clean to the eye; they must be as clean bacteriologically and as sterile as it is possible to make them. This can readily be done by a liberal and intelligent use of boiling water or live steam.

Owing to its material and type of construction, the churn is the most difficult piece of equipment to keep clean. The following method of washing the churn has given good results:—

1. Rinse the churn well with about 50 gallons of clean hot water by revolving a few times in high gear with the vent open. Drain quickly through the doors to avoid accumulation of grease and scum in the churn.

2. Thoroughly wash with a hot solution of alkaline washing powder, using two or three pounds to churn about one-quarter filled. The water during this washing should be brought to the boiling point by putting the steam hose directly in the churn. Revolve the churn in high gear with the vent open for five to ten minutes and drain through the doors.

3. Rinse well with boiling water, revolving the churn in high gear for five to ten minutes.

4. Drain thoroughly and turn the churn with the doors up and open. The churn will quickly dry after this last rinsing in boiling water.

5. Before using, it is recommended that churns be steamed or rinsed first with hot water at least 180° F., and then rinsed and cooled with cold water. In cooling, a large volume of cold water should be run into the churn and the latter revolved in slow gear a long time. The practice of giving a few revolutions with only a small volume of water in the churn does not thoroughly cool the churn, neither does it close the pores in the wood, and the result is a "greasy" condition of the churn. The sticking of the butter is sometimes due to a greasy churn.

6. Churns should be given an occasional liming, but not more frequently than once a week. The excessive use of lime coats the interior of the churn with a lime scale which causes butter to be sticky.

7. The outside of the churn should be washed with warm water (not higher than 120° F.) and a mild soap. Strong alkali and very hot water should not be used.

Lund, of the Ontario Agricultural College, gives the following method of liming a yeast and mould infected churn and was able to reduce the counts in butter to less than 10 per c.c.:—

> "Secure a few lumps (three to five pounds) of fresh unslaked lime and slake by adding small quantities of hot water from time to time. When slaked, add sufficient hot water to make up to 10 gallons or so. Mix well and pour into the churn. Turn steam hose into this milk of lime mixture and bring to the boil. Close churn doors and revolve for fifteen minutes, five minutes at high speed and ten minutes at low speed with worker rollers in gear. Stop churn and bring milk of lime mixture to the boil again. Revolve fifteen minutes more as above. Do not dump out lime mixture, but turn doors to the top and fill to the brim with cold water. Allow churn to stand full of this lime water until required for use again. Empty out lime water and wash out thoroughly with two changes of cold water."

It is advisable to strain the lime solution before putting it in the churn. This will prevent any large particles of lime becoming lodged in the churn and later picked up in the working of the butter.

Liming the churn tends to harden the wood, fills up the pores, excluding curd and grease and keeps it in a clean, sweet-smelling condition.

New churns or churns that have been standing idle for some time should receive special care before using. They should be washed with a hot solution of good washing powder and then treated and soaked for two or three days in a milk of lime solution prepared in the same manner as that recommended above.

When churns have become sticky, due to the pores of the wood becoming clogged with grease and curdy particles, it is necessary to use some chemical to remove this material from the wood. After a thorough washing in the ordinary way, such churns should be treated for at least half an hour with a dilute solution of sulphuric acid, using about one pint of commercial sulphuric acid to 50 gallons of water. Add the water to the churn first and then the acid—never the reverse. After treatment with this dilute acid solution, the churn should be rinsed thoroughly several times with hot water.

The wooden butter ladles and pounder should also be thoroughly washed and then scalded with boiling water after use. Before using again they should be soaked in boiling water and then cooled with clean, cold water.

It is also advisable to have screens or covers made for the doors of the churn to keep out flies and dust while the churn is standing idle. A simple wooden frame, covered with light cotton, can easily be made to fit the churn doors and at a minimum of expense.

## OVERRUN

The overrun in buttermaking is the difference between the pounds of butter fat in the cream churned and the pounds of butter made. It consists principally of water, with salt and small amounts of curd, milk sugar, lactic acid and ash, and is expressed in terms of per cent of the butter fat. In other words, the per cent of overrun is the difference between the pounds of butter made from one hundred pounds of butter fat and one hundred, *e.g.*, if 120 pounds of butter were made from 100 pounds of butter fat, the overrun would be 20 per cent. A great deal of confusion exists in the minds of some buttermakers as to what per cent of overrun really means. They incorrectly think that if butter contains 16 per cent water, 3 per cent salt and 1 per cent curd that the overrun is 20 $(16 + 3 + 1)$ per cent. Butter of such composition would contain 80 $(100 - 20)$ per cent butter fat and, therefore, 100 pounds of butter are obtained from 80 pounds of butter fat, so that 100 pounds of butter fat would give 125 $\left(\frac{100 \times 100}{80}\right)$ pounds of butter or an overrun of 25 (125 — 100 per cent. The two following examples will further illustrate the method of determining the per cent overrun by calculation from the composition of the butter.

### Composition of Butter

| A. | Per cent | | B. Per cent | |
|---|---|---|---|---|
| Fat | 80 | | 81 | Fat |
| Water | 16 | 20—Overrun—19 | 16 | Water |
| Salt | 3 | | 2 | Salt |
| Curd, etc. | 1 | | 1 | Curd, etc. |
| | 100 | | 100 | |

A—80 pounds of fat give 100 pounds of butter
1 pound of fat gives $\frac{100}{80}$ pounds of butter

100 pounds of fat give $\frac{100 \times 100}{80}$ pounds of butter=125

Therefore 125—100=25 per cent overrun.

B—81 pounds of fat give 100 pounds of butter
1 pound of fat gives $\frac{100}{81}$ pounds of butter

100 pounds of fat give $\frac{100 \times 100}{81}$ pounds of butter=123.5

Therefore 123.5—100=23.5 per cent overrun.

The determination of the per cent overrun by calculation from the percentage composition of the butter, as in the preceding examples, gives the theoretical overrun, or the amount of overrun that would be obtained if there were no losses of fat in the process of manufacturing butter. In actual practice, there are unavoidable losses of fat, *e.g.*, in the buttermilk, in butter remaining in the churn, in cream adhering to the pasteurizer, pumps and pipes, etc., so that the actual overrun must be considered. The Actual Overrun may be defined as the difference between the pounds of fat received and paid for by the creamery and the saleable pounds of butter manufactured. By "saleable" pounds of butter is meant the actual number of pounds for which the creamery receives payment, providing all the output be sold, *e.g.* 56½ pounds of butter sold for 56 pounds to take care of the shrinkage would be considered as 56 pounds in determining the actual overrun. In the subsequent discussion of this subject, overrun will refer to actual overrun unless otherwise stated.

The financial success or failure in the operation of a creamery business is very largely dependent on the overrun. The percentage of overrun is controlled entirely by the efficiency of all the men who handle the cream during the different stages of manufacture into butter, by the efficiency of the equipment and by the law regulating the composition of the butter, as will be observed from the following affecting factors.

1. Composition of Butter.—The greater the percentage of non-fatty constituents—water, salt and curd—in the butter, the higher will be the overrun. In Canada it is illegal to manufacture butter containing over 16 per cent water or less than 80 per cent fat. The following table shows the theoretical overrun obtainable from butter of the stated percentage composition. The curd content of butter is fairly constant, averaging about 0.7 per cent. In the following table, 1 per cent represents curd, lactose, acid and ash. The first line of each group gives the maximum theoretical overrun, also the maximum percentage of moisture that may legally be incorporated in butter containing different percentages of salt. It should be observed that when butter contains more than 3 per cent salt, the per cent of moisture incorporated must be less than the legal maximum content (16 per cent) in order to comply with the 80 per cent fat standard, *e.g.*, if butter contained 4.0 per cent salt, 1.0 per cent curd and 16.0 per cent moisture, or a total of 21 per cent constituents other than butter fat, the percentage of fat would only be 79, (100 — 21), and such butter would, therefore, be illegal. This point illustrates the importance of efficiently controlling the salt content of butter, as carelessness in this connection not only adversely affects the quality and overrun of butter, but also may result in the manufacture of illegal butter.

| Group | Percentage Composition of Butter | | | | | Per Cent Overrun |
|---|---|---|---|---|---|---|
| | Salt | Curd | Moisture | Fat | Total | |
| 1 | 0·0 | 1·0 | 16·0 | 83·0 | 100·0 | 20·5 |
| | 0·0 | 1·0 | 15·5 | 83·5 | 100·0 | 19·8 |
| | 0·0 | 1·0 | 15·0 | 84·0 | 100·0 | 19·0 |
| | 0·0 | 1·0 | 14·5 | 84·5 | 100·0 | 18·3 |
| | 0·0 | 1·0 | 14·0 | 85·0 | 100·0 | 17·6 |
| 2 | 1·0 | 1·0 | 16·0 | 82·0 | 100·0 | 22·0 |
| | 1·0 | 1·0 | 15·5 | 82·5 | 100·0 | 21·2 |
| | 1·0 | 1·0 | 15·0 | 83·0 | 100·0 | 20·5 |
| | 1·0 | 1·0 | 14·5 | 83·5 | 100·0 | 19·8 |
| | 1·0 | 1·0 | 14·0 | 84·0 | 100·0 | 19·0 |
| 3 | 1·5 | 1·0 | 16·0 | 81·5 | 100·0 | 22·7 |
| | 1·5 | 1·0 | 15·5 | 82·0 | 100·0 | 22·0 |
| | 1·5 | 1·0 | 15·0 | 82·5 | 100·0 | 21·2 |
| | 1·5 | 1·0 | 14·5 | 83·0 | 100·0 | 20·5 |
| | 1·5 | 1·0 | 14·0 | 83·5 | 100·0 | 19·8 |
| 4 | 2·0 | 1·0 | 16·0 | 81·0 | 100·0 | 23·4 |
| | 2·0 | 1·0 | 15·5 | 81·5 | 100·0 | 22·7 |
| | 2·0 | 1·0 | 15·0 | 82·0 | 100·0 | 22·0 |
| | 2·0 | 1·0 | 14·5 | 82·5 | 100·0 | 21·2 |
| | 2·0 | 1·0 | 14·0 | 83·0 | 100·0 | 20·5 |
| 5 | 2·5 | 1·0 | 16·0 | 80·5 | 100·0 | 24·2 |
| | 2·5 | 1·0 | 15·5 | 81·0 | 100·0 | 23·4 |
| | 2·5 | 1·0 | 15·0 | 81·5 | 100·0 | 22·7 |
| | 2·5 | 1·0 | 14·5 | 82·0 | 100·0 | 22·0 |
| | 2·5 | 1·0 | 14·0 | 82·5 | 100·0 | 21·2 |
| 6 | 3·0 | 1·0 | 16·0 | 80·0 | 100·0 | 25·0 |
| | 3·0 | 1·0 | 15·5 | 80·5 | 100·0 | 24·2 |
| | 3·0 | 1·0 | 15·0 | 81·0 | 100·0 | 23·4 |
| | 3·0 | 1·0 | 14·5 | 81·5 | 100·0 | 22·7 |
| | 3·0 | 1·0 | 14·0 | 82·0 | 100·0 | 22·0 |
| 7 | 3·5 | 1·0 | 15·5 | 80·0 | 100·0 | 25·0 |
| | 3·5 | 1·0 | 15·0 | 80·5 | 100·0 | 24·2 |
| | 3·5 | 1·0 | 14·5 | 81·0 | 100·0 | 23·4 |
| | 3·5 | 1·0 | 14·0 | 81·5 | 100·0 | 22·7 |
| 8 | 4·0 | 1·0 | 15·0 | 80·0 | 100·0 | 25·0 |
| | 4·0 | 1·0 | 14·5 | 80·5 | 100·0 | 24·2 |
| | 4·0 | 1·0 | 14·0 | 81·0 | 100·0 | 22·7 |

A few local markets require a salt content in excess of 3.0 per cent. The creameries catering to such markets should bear in mind that the maximum amount of water that may legaly be incorporated in butter containing 3.5, 4.0, 4.5 or 5.0 per cent salt is 15.5, 15.0, 14.5 and 14.0 per cent respectively.

The following summary of the previous table gives the effect of different salt contents on the maximum theoretical overrun:—

| Per cent Salt in Butter | Maximum Theoretical Overrun Per cent |
|---|---|
| 0.0 | 20.5 |
| 1.0 | 22.0 |
| 1.5 | 22.7 |
| 2.0 | 23.4 |
| 2.5 | 24.2 |
| 3.0 | 25.0 |
| 3.5 | 25.0 |
| 4.0 | 25.0 |

It should be noted from the foregoing tables that the highest theoretical overrun which may be obtained is 25 per cent and that the composition of the butter is a most important factor affecting the percentage of overrun. Just how closely the actual overrun will approach the theoretical overrun will depend on the extent of the mechanical losses of butter fat during manufacture, the accuracy of all creamery weights and tests, and the method of paying for butter fat.

2. Mechanical Losses.—Under this heading is included fat lost in cream spilled on the floor, cream adhering to cream cans, pasteurizing vats, pipes, etc., in the curdy material which forms and remains in the pasteurizer owing to faulty methods of neutralizing, in cream leaking through pumps, pipes and churn doors, in the buttermilk, and in butter which sticks to the churn and is not removed or which is otherwise lost through carelessness. While some of these losses are unavoidable, the reduction in the overrun caused in this way can be considerably lessened by carefulness on the part of the creamery employees. In the case of whole milk creameries, a further unavoidable loss of fat occurs in the skim-milk, which prevents such plants from obtaining as high an overrun as creameries which receive cream skimmed at the farms.

3. Accuracy of Weights and Tests.—Accuracy in the weighing and testing of cream and butter is essential. The overrun is based on the pounds of fat received and paid for by the creamery, so that any inaccuracy in the weighing or testing of the cream obviously affects the percentage of overrun. If the farmer is paid for more fat than is actually received, the overrun will be lowered, while payment by the creamery for less fat than is received increases the percentage of overrun. The utmost care should, therefore, be taken to ensure that the scales for weighing both the cream in bulk and also the samples for testing be in good condition. It is a good practice to test the scales each morning before using with standard weights kept for that purpose only. A 50- and 100-pound weight are suitable for checking the platform scales and a standard 9- or 18-gram weight for checking the weights used with the cream test scales. The sampling and testing of the cream should be done according to standard methods, e.g., as directed in Bulletin No. 14, "The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test", which may be obtained free from the Publications Branch, Department of Agriculture, Ottawa, Ont. Where time permits, it is advisable to check the individual tests of each can of cream with a vat test in the following manner. The pounds of fat for which each patron whose cream enters the vat is paid are totalled, multiplied by 100 and the result divided by the total pounds of cream in the vat. This figure which is known as the "average test", should compare closely with a test of a sample taken after the whole vat has been thoroughly mixed, e.g.:—

$$\begin{aligned}
&\text{Pounds of cream in vat} = 2{,}400\\
&\text{Pounds of fat paid for} = 792\\
&\text{Average test} = \frac{792 \times 100}{2{,}400} = 33.0 \text{ per cent}\\
&\text{Vat test} = 33.3 \text{ per cent}
\end{aligned}$$

Owing to the unrecorded fractions which occur in determining the number of pounds of fat received from each patron, the vat test should be slightly higher than the average test. A wider variation than 0.5 per cent between the average and vat tests indicates inaccuracy in the testing or weighing of the cream.

In actual creamery practice, the buttermaker controls the composition of his butter principally by regulating the moisture and salt content. It has already been stated what effect the composition of butter has on the overrun. The important part that the moisture scales play towards obtaining the desired overrun is, therefore, apparent. If they are inaccurate, the moisture test does not show the true moisture content of the butter and this prevents the intelligent

control of the composition of butter, which in turn affects the per cent overrun. The method of obtaining a representative sample from the churn and the necessity for extreme care in testing the sample for moisture are equally important. Not only does carelessness at this stage of manufacture result in losing control of the overrun, but it also may be the means of manufacturing illegal butter. For detailed information regarding the testing of butter for moisture, the reader is again referred to Bulletin No. 14, "The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test". Moisture scales are a delicate piece of equipment and, as such, require delicate handling. The platform on which they rest should be firmly supported in order to avoid vibrations as much as possible A glass or wooden cupboard protects them from dampness when not in use and also acts as an excellent wind-shield when they are in use. Extreme care should be exercised to keep the moisture scales clean and in perfect order; scales on which portions of butter are adhering cannot be expected to do reliable work. While the average creamery is not equipped to check the accuracy of the moisture scales at the plant, it may be done by submitting samples of butter periodically for moisture tests to their respective provincial dairy departments and by comparing the results with their own tests of the same churnings.

Since the overrun is the difference between the pounds of butter fat bought and the saleable pounds of butter made, it is quite clear that the accuracy of the butter scales and personnel weighing the butter has a very marked effect on the per cent overrun. The scales should be protected from dampness as much as possible and be checked frequently with standard weights as described in the case of the cream scales. For further information regarding the weighing of pound prints and solids, see pages 10-13.

4. Method of Paying for Butter Fat.—The overrun is materially affected by the difference between the pounds of fat received and the pounds of fat paid for by the creamery, which in turn is caused by the fact that in weighing and testing cream there occur unavoidable fractions which cannot be entered in the creamery books. If the actual weight of a can of cream is $69\frac{1}{4}$ pounds, it is recorded as 69 pounds. A test of cream showing $32\frac{1}{4}$ per cent fat would be entered in the creamery books as 32 per cent. In calculating the number of pounds of fat for which a patron should be paid there are fractions which cannot be recognized, e.g., 70.5 pounds of cream testing 30.5 per cent fat contain 21.5025 pounds of fat, but the patron could only be paid for 21.5 pounds of fat. Where payment for butter fat is based on a "give and take" system, in which case fractions of over one-quarter and one-half in the test or weight are recorded as one-half and the next whole number respectively, the overrun will not be as high as when the system described above is practised.

A summary of the foregoing shows:

(I) That the overrun depends on

- (*a*) The composition of the butter;
- (*b*) The law regulating the composition of butter;
- (*c*) The accuracy of weights and tests of cream and butter;
- (*d*) The extent of the mechanical losses in the manufacturing process;
- (*e*) The unavoidable difference between the pounds of fat received and the pounds of fat paid for;
- (*f*) The efficiency of the creamery employees and equipment.

(II) That when the amount of fat lost during the process of manufacture does not exceed the difference between the amount of fat received and the pounds of fat paid for, the actual overrun will be as high as the theoretical overrun.

## LOSS OF FAT IN BUTTERMILK

As one of the factors affecting the overrun and one which may be controlled to some extent by the application of an intelligent knowledge of the conditions which increase or lower the amount of fat lost in the buttermilk, this subject warrants careful study by the thoughtful buttermaker. A loss of 0.5 per cent fat in the buttermilk decreases the percentage of overrun about 1.3 per cent, which on a year's output of 500,000 pounds of butter represents a loss to the creamery of 5,200 pounds of butter. The richer the cream, the less effect loss of fat in the buttermilk has on lowering the overrun owing to the decreased amount of buttermilk, e.g., 100 pounds of cream testing 30 per cent fat contain 30 pounds of fat and 70 pounds of buttermilk. Seventy pounds of buttermilk testing 0.5 per cent fat contain 0.35 $\left(\frac{70 \times 0.5}{100}\right)$ pounds of fat. Therefore, 29.65 (30-0.35) pounds of fat are available to be manufactured into 37.0625 $\left(\frac{29.65 \times 125}{100}\right)$ pounds of butter containing 80 per cent fat. From 30 pounds of fat originally in the cream, 37.0625 pounds of butter are obtained; therefore, every 100 pounds of fat would produce 123.5416 $\left(\frac{37.0625 \times 100}{30}\right)$ pounds of butter, showing an overrun of 23.5416 (123.5416-100) per cent. With no loss of fat in the buttermilk, the overrun would be 25.0 per cent (butter containing 80 per cent fat), so that the reduction of percentage overrun caused by 0.5 per cent loss of fat in the buttermilk equals 1.4584 (25-23.5416).

By substituting the necessary figures in the above calculations, the reduction in per cent overrun caused by 0.5 per cent loss of fat in the buttermilk, will be found to be as follows:—

| Per cent Fat in Cream | Reduction of Percentage Overrun |
|---|---|
| 35 | 1.16 |
| 33 | 1.27 |
| 30 | 1.46 |
| 27 | 1.69 |

The necessity for reducing the loss of fat to a minimum will be appreciated when it is realized that a loss of every 0.1 per cent of fat in the buttermilk represents a loss of more than a thousand pounds of butter to the creamery manufacturing half a million pounds of butter per year.

In view of the fact that the Babcock test as ordinarily used shows only about one-third to one-half of the percentage of fat actually lost in the buttermilk, the need arises for a practical method that will give results corresponding more closely with those obtained by chemical analysis. Such a test, described in "Principles and Practice of Buttermaking," by McKay and Larsen, is as follows:—

1. Place the chemicals and buttermilk in the test bottle in the following amounts and the order indicated:—

   (*a*) 2 c.c. of normal butyl alcohol.
   (*b*) 9 c.c. of buttermilk.
   (*c*) 7 to 9 c.c. of commercial sulphuric acid.

   Vary amount of acid to suit its strength. The right amount is being used when the fat column is golden yellow to light amber in colour.

2. Mix contents of bottle thoroughly.
3. Centrifuge for six minutes.

4. Add hot water (soft or distilled) to fill bottle to bottom of neck and whirl for two minutes.

5. Add balance of water to float fat into neck and again whirl for two minutes.

6. Read at temperature of 130° to 140° F. Double the reading to obtain per cent of fat.

7. In cleaning test bottle—especially if there be any deposit—first add a small amount of lukewarm water and to this add sulphuric acid. Always add the water first and then the acid—never the reverse. Rinse the bottle well with this mixture and then rinse with hot water.

This test gives results corresponding to those of chemical analysis.

A test bottle, with a scale reading up to 0.50 per cent for 18 grams, should be used.

The following table, comparing the Babcock, Butyl Alcohol and Rose-Gottlieb (Chemical) tests, is submitted:—

| Babcock Test[1] Per Cent | Butyl Alcohol Test Per Cent | Rose-Gottlieb Test Per Cent |
|---|---|---|
| 0.38 | 0.52 | 0.52 |
| 0.34 | 0.47 | 0.47 |
| 0.40 | 0.57 | 0.59 |
| 0.43 | 0.60 | 0.60 |
| 0.36 | 0.54 | 0.53 |
| 0.39 | 0.56 | 0.59 |
| 0.36 | 0.50 | 0.52 |
| 0.34 | 0.50 | 0.48 |

Some of the fat in the buttermilk is inclosed in the curd with which it sinks readily to the bottom of the sample on standing. In order to obtain a representative portion for testing it is, therefore, important that the sample be thoroughly mixed before pipetting into the test bottle.

A loss of 0.4 to 0.5 per cent as shown by the butyl alcohol method of testing indicates efficient control of the factors which influence the per cent of fat in the buttermilk.

The following conditions increase the amount of fat lost in the buttermilk:—

1. Pasteurization of thin sour cream.

2. Pasteurization of sweet and sour cream together without thoroughly mixing and holding until the acid is uniformly distributed throughout the cream before pasteurizing. The neutralization of cream before pasteurizing reduces the fat losses in the buttermilk caused by (1) and (2).

3. Churning at too high a temperature.

4. Not holding cream at churning temperature long enough. When conditions (3) and (4) obtain, the larger fat globules form into butter granules very readily, the length of time churning is shortened and thus the smaller globules which have not yet gathered into granules are washed out with the buttermilk.

5. Too much cream in the churn.

6. Speed of churn too low. Conditions (5) and (6) decrease the agitation of the cream, making it more difficult for the small fat globules to coalesce and increasing the number which pass out in the buttermilk. When the churn is too full, there is also the tendency for the cream to swell and foam, which further increases the loss of fat in the buttermilk.

7. Very small butter granules. If the churn is stopped when the butter granules are very small, the smaller fat globules which have not received sufficient agitation to form into granules, will flow out with the buttermilk.

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[1] The Babcock test given in the foregoing table was that obtained from using 12 c.c. of sulphuric acid with a 9-gram sample and centrifuging, in all, about thirty-five minutes in a high speed tester."

8. Thin cream. In thin cream the fat globules are not so close together as in rich cream—there is a greater percentage of serum keeping them apart—and thus they find more difficulty in churning into butter granules. The relatively larger amount of buttermilk from thin cream further increases the loss of fat.

## CHURNING RECORDS

The efficient control of the various processes of manufacturing creamery butter is difficult, if not impossible, unless records be kept of each and every churning. The reasons usually advanced for not keeping records are that the creamery employees have not sufficient time and that the different churnings are so much alike from day to day that little is accomplished by having an exact record for each churning. That such reasons are without foundation is shown by the fact that our most efficient creameries find it advisable to keep churning records. When the record forms and a pencil are hung on a wall near the churn, the time required to write down the churning temperature, ounces of colour used, length of time churning, etc., is almost negligible. It is true that the buttermakers who keep records are able to control the method of manufacture of butter so that little variation occurs in the different churnings, but the very reason they are able to do so is because they have a record of the previous churnings as a guide in their method of handling the present churning. Without that information, the varying seasonal conditions which occur throughout the year make the manufacture of uniform churnings highly improbable.

A knowledge of the number of pounds of cream, the percentage of fat in the cream, the churning temperature and the length of time churning of the previous churnings is a great help to the operator in determining the temperature to which the subsequent vat of cream should be cooled and the temperature at which it should be churned in order that the fat granules will be of the desired mechanical firmness necessary for proper workmanship of butter.

It has already been shown that a uniform colour in butter of different churnings can only be obtained when the number of pounds of fat in the present churning and the rate of colour per hundred pounds of fat used in previous churnings are known.

The control of the moisture content of butter requires a knowledge of the number of pounds of butter expected and of the way the moisture was incorporated in the previous churning.

When salting on the butter granules is practised, it is necessary to know the percentage of salt applied and retained in former churnings.

Churning records assist in the neutralization of cream. When the number of pounds of cream in the vat, the initial acidity, the amount of neutralizer used, and the final acidity are known, the strength of each batch of neutralizing solution may be checked. (See Pamphlet No. 52, " Neutralization of Cream for Buttermaking," page 4.) This is of particular importance where neutralizers whose strength is not constant with different lots are used.

A complete churning record shows the percentage of overrun obtained with each churning—information of vital importance to the financial success of a creamery.

The value of score cards and certificates showing the grading of the butter is greatly enhanced by the keeping of churning records. When a churning of butter is criticized by the graders because of faulty workmanship the buttermaker is able, by studying the record of the churning so criticized, to avoid a repetition of the defects in subsequent churnings by modifying his methods of manufacture.

The following form of churning record may be modified to suit the requirements of the individual creamery:—

Date..
Churning No..
Grade of Cream..
Pounds Cream..
Vat Test..
Average Test..
Pounds Fat..
Pounds Butter Expected..
Initial Acidity..
Amount of Neutralizer..
Final Acidity..
Temperature cooled to..
Number Hours Held..
Churning Temperature..
Ounces of Colour per 100 pounds fat..
Ounces of Colour..
Time Churning..
Temperature of Wash Water..
Number of Revolutions Working..
    (*a*) In Wash Water..
    (*b*) Draining..
    (*c*) After Salting..
Per Cent Salt Applied..
Pounds Salt Applied..
Preliminary Moisture Test..
Pounds Water Added..
Final Moisture Test..
Per Cent Fat in Buttermilk..
Pounds Butter ..
[1]Pounds Scrap..
Per Cent Overrun..
Per Cent Salt in Butter..
Grade of Butter..

## DEFECTS IN BUTTER

Butter grading certificates and score cards specify the defects in butter which is placed in second or off grade. The purpose of the following pages is to be of some assistance in helping to eliminate such defects.

Butter defects may be classified into two main divisions: (1) those of flavour, and (2) those which result from inefficient methods in the process of manufacture, *e.g.*, defects in texture, colour, incorporation of moisture, salting and finish. The former defects are to some extent beyond the control of the buttermaker in that the flavour of the cream as received at the creamery largely determines the flavour of the resulting butter. However, inefficiency in the manufacturing of the butter, *e.g.*, improper methods of neutralizing, unsanitary conditions at the creamery, is sometimes responsible for butter being placed in second or off grade because of defects in flavour, even though there had been no defects in the flavour of the cream when delivered at the plant. The workmanship of butter (2) is entirely under the control of the operator.

### I—Flavour Defects

*Not Clean.*—A large percentage of second grade butter is designated "not clean" by the graders. This flavour defect is caused by unsanitary conditions obtaining either at the farm or in the creamery, *e.g.*, dirty stables, unclean milk pails and strainers, not washing the farm separators after each separation, shipping cream in cans that have not been properly washed, steamed and dried, unclean equipment in the creamery.

[1] Refers to butter scraps left over from previous churnings and added to the present churning.

*Yeasty.*—Unsanitary conditions and insufficient cooling of the cream at the farm, heating of the cream in transit during the hot summer weather and holding the cream too long at the farm are mainly responsible for this flavour defect.

*Neutralized.*—A neutralized flavour in butter is caused by over-neutralization or improper methods of neutralization of sour cream. For correct methods of neutralization, see Pamphlet No. 52, "Neutralization of Cream for Buttermaking."

*Cheesy.*—A cheesy flavour in butter is usually associated with a high curd content, the result of churning high acid cream and insufficient washing of the butter granules. The neutralization and pasteurization of cream and thorough washing of the butter granules lessen the tendency of butter made from very sour cream to develop this flavour.

*Musty.*—A musty flavour in butter may be caused by one or more of the following practices:—

Feeding mouldy hay, mouldy silage and musty grain to the cows.
Keeping cream in damp, poorly ventilated cellars.
Not cooling each separation of cream before adding to the main supply at the farm.

*Gasolene.*—Butter having this defect is very objectionable and is placed in third grade. Wherever a gasolene engine is used, either for cream separation at the farm or as motive power in the creamery, the strictest precautions should be taken to avoid a gasolene flavour in the cream and butter. The following suggestions will assist in preventing the absorption of gasolene flavour by cream:—

(1) All possibility of the entrance of fumes from the engine exhaust into the separator room must be avoided. This can be effected by having a tight connection between the engine and exhaust pipe and by directing the pipe through the roof instead of through the wall of the building. By this arrangement, no matter what direction the wind may be, the fumes are blown away from the cream.

(2) A tight wooden partition between the separator and the engine helps to keep gasolene odours from the cream.

(3) When possible, arrange the equipment so that the separator is between the direction from which the most prevalent winds blow and the engine.

(4) The operator should practise the utmost care when handling gasolene and the engine to avoid carrying gasolene odours on his hands and clothing.

(5) Never place gasolene in a cream can, milk pail or any dairy utensil.

*Feed.*—Such feeds as turnips and turnip tops, rape, rye, decayed ensilage, leeks, onions and apples (in large quantities) injure the flavour of butter. When turnips are fed, they should be given to the cows *after* milking and every precaution should be taken to keep the milk and cream from absorbing the flavour from turnips stored in or near the barn. Turnip tops should not be fed to milch cows.

*Weedy.*—Rag-weed, stink-weed, sage-brush, leeks and garlic produce objectionable flavours in butter made from cream from cows that have access to these weeds. The eradication of such weeds from the pastures is the only practical method of avoiding second grade butter from this source.

*Rancid.*—Rancidity is a common flavour defect in butter that has been stored a long time. The efficient neutralization and pasteurization of cream, thorough washing of the butter granules to ensure a low curd content. protection of the butter from air, light and heat, and extreme care in cleaning and sterilizing creamery equipment, are the precautions suggested in order to avoid the development of rancidity in butter.

*Fishy.*—Butter made from high acid cream usually develops a fishy flavour in storage. It has also been demonstrated that the overworking of butter produces fishiness. In order to avoid this defect, the following recommendations are given.

Neutralize sour cream to about .25 per cent acid before pasteurization.

Avoid overworking the butter.

Do not allow copper surfaces of creamery equipment with which the cream comes in contact to become exposed—keep them well tinned.

*Metallic.*—The cause of metallic flavour in butter has not yet been definitely established. It is known that this defect is associated with high acid cream, rusty cream cans, rusty utensils at the farm and the copper surfaces of creamery equipment with which the cream comes in contact being exposed, although these conditions do not always cause metallic flavours in butter. The foregoing contributing causes suggest that cream be neutralized to about .25 per cent before pasteurization, that vats, coils, cream cans, etc., with which the cream comes in contact be kept well tinned and that cream cans be thoroughly cleaned, steamed and dried before being returned to the farmer.

*Burnt, Cooked or Scorched Flavour.*—The cooked flavour resulting from high pasteurization temperatures leaves the butter after a few days' storage and is not looked on with disfavour by butter graders. There is another kind of burnt flavour which is caused by the activity of a certain organism[1] and which, unlike the flavour caused by high pasteurization temperatures, does not leave the butter. While the two flavours resemble each other, Hammer & Cordes[2] state that:—

> "The experienced butter judge recognizes a pronounced difference between the so-called burnt flavour and the flavour that results from excessive pasteurization exposures. It suggets caramel to some people and the flavour of condensed milk to others, while still others believe it is more suggestive of malt. The term 'caramel' is accordingly proposed as a designation for this flavour."

Butter having the caramel flavour is objectionable to the trade and is placed in second grade by the butter graders.

> "Neutralization and pasteurization will not prevent the caramel flavour in butter if it is present in the cream. The organism causing this flavour defect may be present in cow feces, in water in cream cooling tanks and is apparently widely distributed."

The two latter statements suggest the following precautionary measures:—

Efficient cleaning and sterilization of dairy utensils at the farm and of cream cans at the creamery.

Milking in clean stables.

A clean condition of cows' udders and teats at milking time.

The grading of cream at the creamery and not allowing the caramel flavoured cream to be mixed with the first grade churnings.

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[1]Sadler, Wilfrid, (1926) Trans. Roy. Soc. Canada, Ser. III, Sec. 5.

[2]Research Bulletin No. 68, Ames, Iowa.

## II—Defects in Workmanship

*Weak Texture.*—The texture of butter depends on the mechanical condition of the fat granules and on the manner of working the butter. The various factors which affect the condition of the fat, *e.g.*, breed of cows, period of lactation, feed of cows, churning temperature, length of time holding the cream at churning temperature, etc., and directions regarding the working of butter have already been stated. A weak textured butter results when cream is churned at too high a temperature, when cream has not been held long enough at the churning temperature before churning, and when butter in a soft condition is overworked. If, through incorrect treatment of the cream prior to churning, the butter granules are soft, this condition may be remedied within certain limitations. See page 6, Temperature of Wash Water.

*Open Texture.*—Present day markets demand a close textured butter. Insufficient working of the butter, especially when the butter granules are in a very firm condition, is the cause of open texture. See page for determining when the butter has received the correct amount of working.

*Greasy Texture.*—Greasy texture is caused by overworking the butter when in a soft condition, the result of too high a churning temperature, not holding the cream long enough at the churning temperature before churning allowing the butter granules to warm up in the churn before working, or too high a temperature of the wash water. See pages 3, 6.

*Salvy Texture.*—The overworking of butter when in a very firm condition results in a salvy texture. This defect is more common in butter made in the winter owing to the hard nature of the fats at that time of year. See also under Churning Temperature, page 3.

*Sticky Texture.*—A sticky churn, overworking the butter, and excessive liming of churns are mainly responsible for a sticky texture. For methods of treating a sticky churn, see page 14.

*Brittle Texture.*—The problem of avoiding this defect in butter confronts the buttermaker in the winter when the fats are in a very firm condition and when the fat globules in the cream are relatively very small. The effect of these conditions in producing brittle butter may be lessened by using higher temperatures for churning and washing and by thoroughly working the butter.

*Mealy Texture.*—The slow heating and cooling of cream tends to induce mealiness in the butter. In order to avoid this condition, there should be a good fire under the boiler, a good head of steam and plenty of water in the boiler before pasteurization is begun; in cooling, every precaution should be taken to speed up the operation. The coil of the pasteurizer should be kept revolving during the whole process of pasteurization to eliminate the possibility of the " oiling off " of the hot cream. When the hot cream has been allowed to " oil off," the fat develops a granular texture during the cooling of the cream and the result is a mealy butter. Adding scraps of butter from a previous churning to cream during pasteurization at a temperature higher than 100° F. causes a mealy textured butter. A careful study by Hunziker[1] has shown that frozen cream when thawed at a temperature not exceeding 95° F. will not cause mealiness in butter.

[1] "The Butter Industry" by O. F. Hunziker, La Grange, Illinois.

*Free Moisture, Leaky Moisture.*—" Free Moisture " refers to butter which, when bored, shows small drops of water on the back of the tryer. Such butter, when otherwise fit to be classified as first grade, is not placed in second grade. When the drops are sufficiently large to drip off the end of the butter tryer, the butter is termed " leaky " and is placed in second grade, even though the flavour of the butter be suitable for first grade. Fat granules from cream that has received proper treatment regarding churning temperature and time of holding prior to churning will be of such firmness as to allow sufficient working to ensure the efficient incorporation of moisture. See page 4. Too high a churning temperature results in a weak bodied butter which does not permit of sufficient working to properly incorporate the moisture, as described on pages 8, 9.

*Milky Brine.*—" Milky Brine " refers to butter which, when bored, shows milky drops of moisture on the back of the tryer. Such a defect is very objectionable and causes the buter to be placed in third grade. Neglect to properly wash the buttermilk from the butter granules is responsible for this defect and results in a butter of very poor keeping quality.

*Uneven Colour.*—Butter which is slightly mottled, or slightly streaky, or of an objectionable shade is placed in second grade. A very mottled or streaky colour causes butter to be classified as third grade. Colour defects are caused by the uneven distribution of the salt throughout the mass of butter; which is the result of:

(1) Faulty mechanical condition of churn and rollers.
(2) Insufficient working of butter.
(3) Churning more butter than the rated capacity of the churn.
(4) Using salt of poor quality—not readily soluble.
(5) Butter granules not firm enough to stand the pressure required for sufficient working.
(6) Butter working to the ends of the churn and, therefore, not receiving uniform working.

Saltless butter is sometimes uneven in colour. The writer recently inspected several car-loads of saltless butter which were decidedly uneven in colour. In the case of one creamery, an investigation showed that this defect in saltless butter was caused by too wide a variation between the temperature of the wash water and that of the butter granules and by churning to too large granules. The buttermaker was aiming to reduce the loss of fat in the buttermilk by churning at very low temperatures, resulting in very firm granules and requiring wash water of a relatively high temperature in order to bring the butter to a suitable consistency for working. The outside of the granules was softened by the wash water, but the centres remained firm and this variation in the consistency of the butter was responsible for the uneven colour. When the size of the butter granules was reduced and the temperature of the wash water brought nearer to that of the butter granules, the defect in the butter did not appear. See also page 6, Temperature of Wash Water.

*Lack of Uniformity in Colour of Different Churnings.*—For export to European markets, a light straw coloured butter is desired. It is most important that the colour of all our export butter be as uniform as possible. Lack of uniformity in the colour of different churnings from the same creamery is considered a serious defect by the butter graders. See also page 5.

*Salt too Heavy.*—Butter which contains more than 2 per cent salt for the British market cannot receive a special or first grade score, unless the grader is notified that the butter is for a special market. A "too heavy" salt content causes butter to be placed in second grade, and "exceedingly heavy" in third grade. For directions regarding the control of the salt content of butter, see pages 8-10.

*Salt Undissolved.*—Butter containing undissolved salt cannot be placed in special or first grade. This defect is caused by insufficient working of the butter, applying more salt than the moisture content of the butter is capable of holding in solution, and the use of poor quality salt.

*Packing.*—The following defects in packing cause butter to be placed in second grade:—

Unseasoned material in the boxes, rough, badly made, or dirty boxes.
Poor parchment paper.
Poor finish, uneven weights.

See also pages 11-13.

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